PulseGAN: Learning to Generate Realistic Pulse Waveforms in Remote Photoplethysmography

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Abstract

Remote photoplethysmography (rPPG) is a non-contact technique for measuring cardiac signals from facial videos. High-quality rPPG pulse signals are urgently demanded in many fields, such as health monitoring and emotion recognition. However, most of the existing rPPG methods can only be used to get average heart rate (HR) values due to the limitation of inaccurate pulse signals. In this paper, a new framework based on generative adversarial network, called PulseGAN, is introduced to generate realistic rPPG pulse signals through denoising the chrominance (CHROM) signals. Considering that the cardiac signal is quasi-periodic and has apparent time-frequency characteristics, the error losses defined in time and spectrum domains are both employed with the adversarial loss to enforce the model generating accurate pulse waveforms as its reference. The proposed framework is tested on three public databases. The results show that the PulseGAN framework can effectively improve the waveform quality, thereby enhancing the accuracy of HR, the interbeat interval (IBI) and the related heart rate variability (HRV) features. The proposed method significantly improves the quality of waveforms compared to the input CHROM signals, with the mean absolute error of AVNN (the average of all normal-to-normal intervals) reduced by 41.19%, 40.45%, 41.63%, and the mean absolute error of SDNN (the standard deviation of all NN intervals) reduced by 37.53%, 44.29%, 58.41%, in the cross-database test on the UBFC-RPPG, PURE, and MAHNOB-HCI databases, respectively. This framework can be easily integrated with other existing rPPG methods to further improve the quality of waveforms, thereby obtaining more reliable IBI features and extending the application scope of rPPG techniques.